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Acid Deposition Research Program

Alberta Government/Industry
Acid Deposition Research Program

Final Report

April 1, 1988 to March 31, 1989

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MAY 25 1989

This report marks the sixth year and the completion of a unique environmental research program.

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Members Committee Report

What are Acid-Forming Gases and Acid Deposition?

Worldwide, the processing and burning of fossil fuels produces sulphur and nitrogen oxides. In the atmosphere, sulphur dioxide and nitrogen oxides can be converted chemically to sulphuric acid and nitric acid, among other products. These two acids, as well as other substances, can fall to earth as wet deposition in rain, snow, sleet, or hail. Through another process, dry deposition, these oxides fall to the earth and can combine with surface moisture to form acids. (Acid deposition is a broader term than acid rain, but the two are often used interchangeably.)

The key question for the ADRP researchers was: "What environmental changes, if any, do the current atmospheric levels of acid-forming gases produce in Alberta?"

It is with a tremendous sense of accomplishment that we are providing this, our last report on the Acid Deposition Research Program (ADRP). Six years ago, the ADRP was formed on a foundation of 10 years of work by government, industry, and the public on the complex questions related to acid-forming emissions. The ADRP's main objective was to provide a comprehensive understanding of the effects and consequences of acid forming gases on the environment of Alberta. We had set out to achieve one of the most unique environmental research programs ever conducted.

Today, we believe that as a result of the work and studies, Albertans have one of the soundest bases of scientific knowledge available in the areas of air pollution and acid deposition. This knowledge will be invaluable in helping us to determine the policies that govern our environment.

But why is this program so unique? We believe the uniqueness is reflected in the fundamental structure of the ADRP:

- Government and industry, in a co-operative, up-front manner, agreed to a major financial undertaking that would span six years.

- Inherent to the agreement was the commitment to scientific integrity.

To this end, more than 20 internationally-respected scientists formed the ADRP's

Scientific Advisory Boards. Included were statisticians, atmospheric modelers, forest pathologists, meteorologists, chemists, epidemiologists, toxicologists, social geographers and demographers.

These scientists demanded and received assurance from the ADRP that the science would in no way be influenced by the funding members. These scientists provided the planning and design components, and the guidance, evaluation and peer review of all work conducted by the research contractors.

• The public involvement component was essential to the program, and sets a model for future research initiatives. Through a combination of scientific and public input, the ADRP's program took shape. Then, throughout the six years, the input of our Public Advisory Board was extremely valuable with respect to relevance of the scientific work.

The Board's advice on communication to Albertans and other audiences helped to make complex scientific issues understandable. Over the course of the program, the ADRP's communications work won four awards of excellence from professional associations in the communications field.

• The transfer of knowledge and technology between the university and private sectors was an indirect benefit of the research programs, and reflects the complementary strengths of the members of the research teams.

Highlights of the Work Undertaken

Through the Acid Deposition Research Program, $10.4 million was committed to two major areas of study: human health and the potential effect of acid deposition on the natural biophysical system (Alberta's air, soils, waters and crops).

In these areas, the ADRP administered three research studies:

1. 1985-1986 The Southwest Alberta Medical Diagnostic Review (Pincher Creek Health Study)

This $3.7 million study, funded by the Alberta Department of Community and Occupational Health, is one of the largest community health studies ever undertaken. This "blue ribbon study" was undertaken to address more than 20 years of confusion and health concerns voiced by the residents near Pincher Creek, in southwestern Alberta. Concerns were attributed to local sour gas plant emissions.

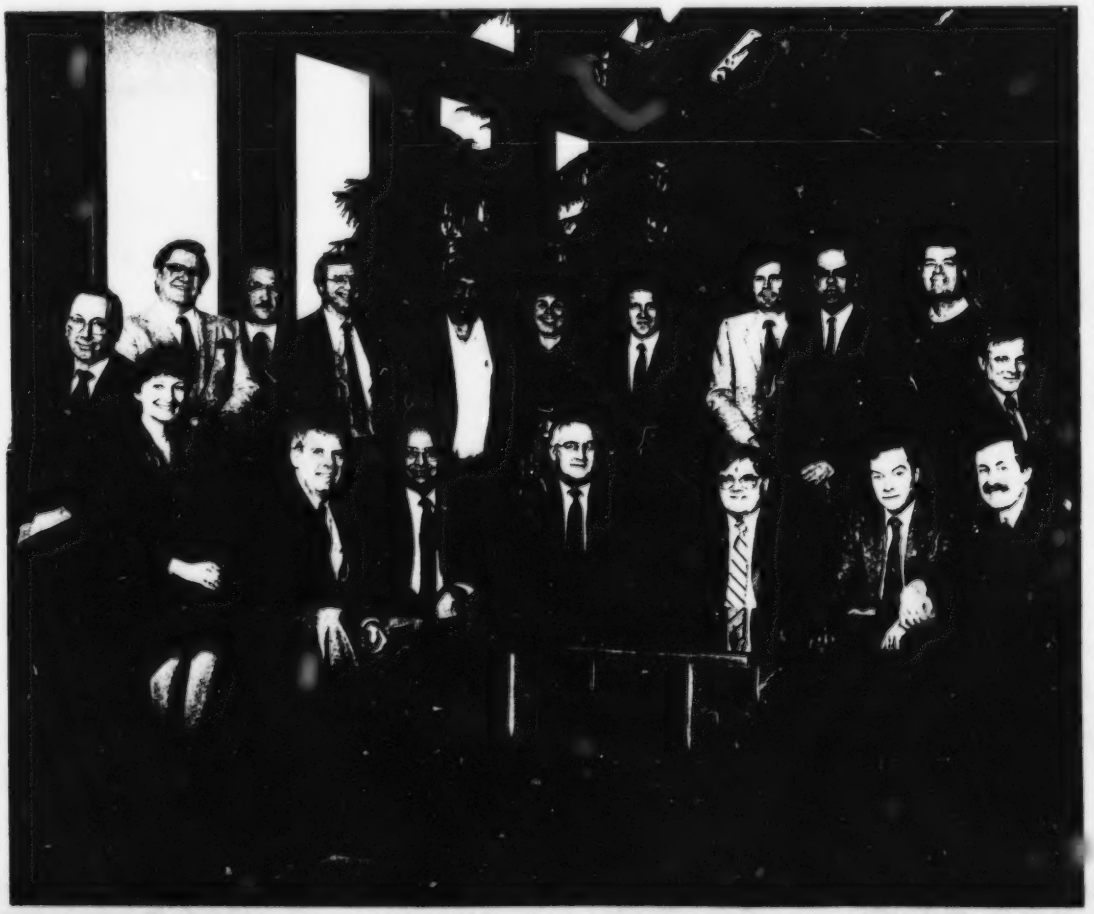
More than 80 medical experts and support personnel led by McGill University conducted the work. The team also included scientists and researchers from the Universities of British Columbia, Laval, Harvard and Yale, the Mayo Clinic, York University and the University of Texas.

Fortunately, the study reassured residents in the Pincher Creek area that their community was healthy by any Canadian standard.

Subsequent to the main study, in March 1989, Principal Investigator Dr. Walter Spitzer met with the community's advisory board. He provided the results of a further selenium analysis which had been requested by the ADRP's Science Advisory Board. The follow-up analysis was conducted to determine if the naturally occurring low selenium levels in the area identified during the main study might have any implication in terms of human health. After the analysis, both members of the McGill team and the Science Advisory Board agreed that "there are no adverse health effects which can be ascribed to either a high or low hair selenium level" in the Index Area.

2. 1985-1988 Biophysical Research Program on the Present and Potential Effects of Acid Deposition on the Environment of Alberta

This $5.3 million study, funded by the ADRP, has been rated by scientists as one of the most comprehensive air pollution studies ever conducted in the world. The research contract to study the present and potential effects of acid deposition in Alberta was awarded to a university-private sector team led by the University of Calgary's Kananaskis Centre.



The Members Committee of the ADRP, with its Public Advisory Board. From left to right (M denotes Member; P denotes Public Advisory Board) front row:
Jean Andryiszyn, communications co-ordinator;
Dr. John Railton (M), utilities representative;
Dr. Lochan Bakshi (P), Public Advisory Committee of the Environment Council of Alberta and Athabasca University;
Ron Findlay (M), industry co-chairman, Canadian Petroleum Association;
Ken Smith (M), government co-chairman, Alberta Environment;
Dr. Dixon Thompson (P), Science Advisory Committee of the Environment Council of Alberta, Alberta Society of Professional Biologists, Canadian Society of Environmental Biologists, and the University of Calgary;
Dr. Ron Wallace, program manager;
(back row)
Ed Brushett (M), Energy Resources Conservation Board;
Ed Collom (M), Alberta Community and Occupational Health;
Dennis Gogal (P), Environmental and Outdoor Education Council of the Alberta Teachers' Association;
Hank Gauthier (P), Energy and Chemical Workers Union;
Sam Sinclair (P), Alberta Aboriginal Peoples;
Susie Washington, moderator, Public Advisory Board;
Dr. Nick Bayliss (P), Alberta Health Care Associations;
Herman Bulten (P), Christian Farmers Federation and other agricultural associations;
Dr. Casey Van Teeling (M), Alberta Environment;
Doug Bruchet (M), Canadian Petroleum Association; and
Dr. Percy Sims (M), Alberta Environment.
Not pictured,
Prof. Eric Tollefson (P), University of Calgary, and the Association of Professional Engineers, Geologists and Geophysicists of Alberta;
Dr. Harby Sandhu (M), Alberta Environment;
Carl Primus (M), Alberta Community and Occupational Health.

Twenty scientists supported by technical and other staff investigated the potential impacts of acid deposition on Alberta's air, soils, waters and crops.

According to the Science Advisory Board, the air monitoring work conducted as part of this study at Fortress Mountain "will serve as a benchmark for the rest of Canada and the United States.... The results of the monitoring exercises have generated a data base of air quality unmatched elsewhere in the world."

In general, the scientists concluded that regional scale impacts of acid rain in Alberta are not demonstrated today, and likely absent. They have, however, cautioned that greater industrialization will increase the risks associated with pollution in parts of the province identified as sensitive.

A more detailed summary of the objectives, conclusions and recommendations of this work follow in this annual report, page 7.

3. 1985-1986 Feasibility Study - Occupational Health

A $25,000 feasibility study, also funded by the ADRP, was conducted by the Faculty of Medicine, University of Alberta, to determine whether it was possible to do further research into the occupational exposure of workers in Alberta's sweet gas, sour gas and thermal plants.

The researchers concluded it was, and recommended a three-stage strategy anticipated to cost $1 million. Because of the very specific nature of the study, the ADRP has referred the project to industry and occupational health areas of government for funding consideration.

What Does This Work Mean to Albertans?

As stated in the charter of the Acid Deposition Research Program, one of the program's main commitments was to establish a scientific base which will help Albertans determine the policies for sound, long-term environmental management and regulatory control. We achieved this objective.

We also have reviewed the conclusions and recommendations of the research scientists, the Science Advisory Boards and our Public Advisory Board. (See page 12 for the biophysical scientists' recommendations and page 18 for the Public Advisory Board's recommendations.) The Members concur with these recommendations, and we have communicated them to the ADRP's funding agencies and to the appropriate agencies and individuals in Alberta for further action.

To ensure Albertans have access to sound environmental management data, the Members Committee concludes:

- Mechanisms to fund and support scientific baseline air quality monitoring have been referred to the Minister of Alberta Environment to explore this issue between the appropriate federal and provincial agencies.

- Alberta Environment should evaluate the need to undertake specific research to ensure the protection of sensitive environments identified by the ADRP program. This conclusion, along with the specific recommendations of the PAB and SAB, have been referred to the Minister of Alberta Environment.

- The Members Committee recognizes the comprehensive evaluation of the Medical Diagnostic Review (MDR) study carried out by the Science Advisory Board in 1986. That Board recommended as follows:

"3. We also concur with the third recommendation of the Report concerning the inadvisability of new data collection concerning the health status of residents in the Index Area. The very comprehensive studies incorporated in the MDR should be regarded as the definitive examination of the health of residents in the region. However, the results of the MDR do not exclude the possible need for future studies of health effects of specific industrial pollutants in Alberta.

4. In order to determine if the naturally occurring low selenium levels in the Index Area might have any implications in terms of human health, limited additional analyses of data already available in the MDR should be carried out. It should be determined whether subjects with undetectable hair levels of selenium show an excess of adverse health affects which might be ascribable to a low selenium status. If this is found, additional studies of this specific question may be indicated." (Science Advisory Board Final Review, 1986, pg. 30.)

This special study on selenium effects was completed and presented to the Community Advisory Board at Pincher Creek in early 1989. The completion of this last component fulfills the administrative mandate of the Members Committee for the completion of the Medical Diagnostic Review.

- The results of the Occupational Health Feasibility Study have been communicated to the Department of Community and Occupational Health and to the Health Sub-Committee of the Canadian Petroleum Association.

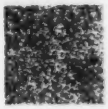
- While outside the strict Terms of Reference for the ADRP, the Members Committee recognizes that there is a need to conduct detailed veterinary health studies in the province, particularly in specific areas of acidic emissions. The Members Committee recognizes the need to follow-up on this veterinary health research program, and accordingly has transmitted the recommendation to the Alberta Environment Centre at Vegreville, Alberta.

A Mandate Fulfilled

The ADRP has fulfilled the terms of its mandate with the help and commitment of hundreds of Albertans, the scientific community, and the financial and human resources of its funding members. We extend our sincere thanks to all of those who helped us achieve our goals.

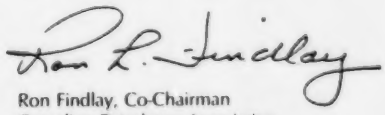
In undertaking the Acid Deposition Research Program, the funding members did so with a heightened sense of environmental awareness and the recognition that only with a sound knowledge base can environmental protection measures make sense.

But the greatest legacy of the ADRP goes beyond the scientific knowledge gained today. We hope that the ADRP, with its commitment to co-operation, scientific excellence and integrity, and public involvement and communication, will help serve as a model -- that can be refined and strengthened for future research initiatives.



On Behalf of the Members Committee

Ken Smith, Co-Chairman
Alberta Environment



Ron Findlay, Co-Chairman
Canadian Petroleum Association

What Were The ADRP's Objectives?

1. To provide a comprehensive understanding of the effects and consequences of acid-forming gases on the environment.

2. To provide a scientific basis for sound, long-term environmental management and regulatory control with respect to acid-forming gases.

3. To disseminate such information among members, to the public and to government bodies.

4. To undertake any research deemed appropriate.

5. To encourage and include opportunities for public representation in the ADRP.

Membership and Percentage Participation In The Acid Deposition Research Program

Members	Percentage Participation for Voting and Funding
The Minister of Environment	50.00
Canadian Petroleum Association	34.60
Energy Resources Conservation Board	10.00
Utilities Group	5.40
- TransAlta Utilities Corporation	
- Alberta Power Limited	
- The City of Edmonton	
Public Member	—
TOTAL	**100.00%**

ADRP Members Committee 1988-89

Ken R. Smith (Co-Chairman)
Assistant Deputy Minister
Alberta Environment

Ron L. Findlay (Co-Chairman)
General Manager,
Environmental Affairs and Safety
Amoco Canada Petroleum Co. Ltd.
Canadian Petroleum Association

Douglas Bruchet (Treasurer)
Manager, Environmental and Socio-Economic Development
Canadian Petroleum Association

Dr. Cornelius (Casey) G. Van Teeling (Secretary)
Alberta Environment

Ed. R. Brushett
Manager, Environment Protection
Energy Resources Conservation Board

Dr. John Railton
Special Projects Manager
Monenco Consultants Limited
Utilities Group Representative

Ed. A. Collom/Carl Primus
Environmental Health
Alberta Community and Occupational Health

Dr. H. Percy Sims (Special Advisor)
Alberta Environment

Dr. Harby S. Sandhu (Special Advisor)
Alberta Environment

Moderator Public Advisory Board:
Susie Washington

Program Manager:
Dr. Ron Wallace

Communications Co-ordinator:
Jean L. Andryiszyn

Special Report – Biophysical Research

In September 1988, the Acid Deposition Research Program released the results of its $5.3 million study on the present and potential effects of acid deposition in Alberta. This study was conducted between 1985 and 1988 and represented one of the major components of the ADRP's work.

The scientists who conducted the research and the Science Advisory Board which reviewed all aspects of the work concluded that regional scale impacts of acid deposition in Alberta are not demonstrated today, and likely absent. They cautioned, however, that greater industrialization will increase the risks associated with pollution in parts of the province they have identified as sensitive.

The independent Science Advisory Board (SAB), composed of eleven air pollution specialists, has rated this research as one of the most comprehensive studies of air pollution in the world. In its report, the SAB said that the air monitoring work conducted as part of this study at Fortress Mountain "will serve as a benchmark for the rest of Canada and the United States.... The results of the monitoring exercises have generated a data base of air quality unmatched elsewhere in the world."

A university-private sector team, led by the University of Calgary's Kananaskis Centre for Environmental Research, carried out the study. Specifically the scientists concluded:

"Regional scale impacts of acid deposition on crops, soils, and surface waters today are ***not*** *demonstrated and likely absent, with a slight reservation in the area of possible small impacts on alfalfa growth in a few areas. Large increases in average deposition levels, however, could impact alfalfa and similarly susceptible vegetation in areas that also experience high concentrations of ozone, and increased deposition of acidic and acidifying pollutants could acidify soils and surface waters in a few susceptible areas."*

The area identified by the scientists to have **possible** small impacts on alfalfa is northwest of Edmonton. In this study, the scientists extensively analysed actual alfalfa yield data for three locations in Alberta: Cold Lake, Crossfield and Barrhead. In the Barrhead area only, the actual yield appears to be lower than yields predicted by the models used in the scientific analysis. Verification of this by actual field study is recommended.

Impact on wheat growth was also examined for Alberta but no negative effects were indicated. However, the study concluded that a number of soil types in forest areas and certain lakes in heavily forested areas were sensitive to increased pollution.

The scientists determined that the concentrations of acid-forming pollutants in Alberta – even in regions influenced by highways, cities and industrial plants – are extremely low. According to Dr. Sagar Krupa, chairman of the Science Advisory Board, "Whether you make comparisons with the pristine conditions at Fortress Mountain

(continued p. 9)

Sites of Biophysical Research and Human Health Research

Biophysical

The research work at the Crossfield sites included local and regional air quality assessments and agricultural crops and soils evaluation with respect to acidic deposition. The Fortress site was used as a "background" or comparison area, to determine the quality of air entering Alberta.

The Scientific Advisory Board approved the Crossfield site for this work for a number of important reasons:

1. The proximity to the large urban centre of Calgary, the major transportation corridor of Highway 2 north, local and regional industrial emissions and appropriate wind patterns were key factors leading to Crossfield's selection.

2. At this site the researchers evaluated sulphur dioxide, hydrogen sulphide, hydrocarbons, oxides of nitrogen, ozone, carbon dioxide and trace metals. This evaluation helped researchers integrate ADRP's biophysical and health research programs by describing and quantifying the chemical nature of the atmosphere in Southern Alberta.

Human Health

The main study area, or Index Area, for the Medical Diagnostic Review (conducted in 1985-1986) included several communities near Pincher Creek, Alberta. An area southeast of Lethbridge, including Stirling/Raymond, and an area northwest of Calgary, including Crossfield, served as comparison communities in this major community health study.

or to one of the world's most polluted areas, acid pollutants in Alberta's air are at low concentrations. The finding, however," stressed Dr. Krupa, "should not be interpreted to say that there are **no** environmental concerns in Alberta. There are some sensitive areas that could be affected if the pollution levels -- or the mix of pollutants -- increase dramatically."

"One of the scientific findings, which was a complete surprise to us, relates to this caution," added Dr. Legge, who was the lead scientist of the team which conducted the study. "On a number of occasions, the scientific team detected the long-range transport of ozone into Alberta from British Columbia and the State of Washington. This is the first time that the long-range transport of ozone has been observed in Western Canada."

One of the mandates of the scientific team and the Science Advisory Board was to make recommendations to the ADRP on what types of future research would be most productive, adding to the body of knowledge we now have. "The major recommendation for future scientific work is to focus on the areas identified as sensitive in Alberta. Now we have a narrower field to deal with and we can focus on the sensitive areas, verify the findings of work to date, and consider the effects of combinations of pollutants," said Dr. Krupa.

The Scientific Study Team

The biophysical research contract was awarded in January, 1985 to a university-private sector team headed by the Kananaskis Centre for Environmental Research of The University of Calgary. The Principal Investigator was Dr. Allan Legge.

The research contract involved more than 30 professional scientists plus technical support personnel. Besides the resources of the Kananaskis Centre, the scientific expertise of individuals from the following organizations and companies was retained to assist the ADRP:

- ASL and Associates, Helena, Montana
- Alberta Research Council, Terrain Science Department, Edmonton, Alberta
- Aquatic Resource Management, Ltd., Calgary, Alberta
- Carnegie Mellon University, Department of Civil Engineering, Pittsburgh, Pennsylvania
- Ecosat Geobotanical Surveys Inc., North Vancouver, British Columbia
- Element Analysis Corporation, Tallahassee, Florida
- Emporia State University, Department of Biology, Emporia, Kansas
- Florida State University, Department of Oceanography, Tallahassee, Florida
- Illinois State Water Survey, University of Illinois, Champaign, Illinois
- Lawrence Livermore National Laboratory, Environmental Sciences Division, Livermore, California
- McVehil-Monnet Associates, Englewood, Colorado
- Nuclear Element Analysis (NEA), Inc., Beaverton, Oregon
- Subsurface Technologies, Ltd., Calgary, Alberta
- The University of Calgary, Department of Biology, Department of Geography, Kananaskis Centre for Environmental Research, Department of Mathematics and Statistics, Department of Physics, Calgary, Alberta
- U.S. Department of Agriculture, Beltsville, Maryland
- Western Research, Calgary, Alberta

Study Background — How Was The ADRP Biophysical Research Done?

The ADRP's biophysical research study dealt with two questions:

1. Are there at present, observed or measurable adverse effects of acidic or acidifying pollutants on Alberta's vegetation, soils and surface waters?

2. If the answer to objective (1) is negative, when, where, and under what circumstances will such adverse effects occur in Alberta?

This study, which considered many sources of emissions, was to develop a **regional** scale assessment of environmental effects within Alberta. It is critical to note that this was neither a study of any one specific source of emission or of "one chimney or smokestack", nor did this study specifically deal with pollution in urban centres, indoor pollution or accidental releases of pollutants.

The contract for the study was awarded to the University of Calgary's Kananaskis Centre for Environmental Research in 1985. Four steps were taken by the scientists to meet the study's objectives:

Step 1: World literature reviews were conducted early in the program. Studies done throughout the world on acid deposition were reviewed, with particular attention to cause-effect relationships - e.g., under what conditions, how much and what type of a given pollutant must be present, and how long must it be present before an effect is seen.

The result of this undertaking was an 11-volume, 1,300-page review which provided the scientists with an understanding of where, when, and under what conditions adverse ecological effects had been observed by others. The reviews also made initial observations on how the world-wide information relates to Alberta's environment.

Step 2: A comprehensive measurement and description of Alberta's air quality was done. This involved the installation and operation of three sophisticated air monitoring stations. The stations measured the chemical make-up of the atmosphere and meteorological conditions. These measurements involved the study of air pollution in the form of gases, particles, and rain, as well as wind speed and direction, temperature, barometric pressure, precipitation, humidity, and radiation. An air monitoring station located at Fortress Mountain obtained data on the quality of air entering Alberta. The scientists refer to this as "background air quality".

The other two air monitoring stations were located near a source of industrial emission (a gas plant) near Crossfield. The Crossfield West station sampled air modified by agricultural activities and by the general level of human activity in Alberta. Crossfield East added to this data by measuring pollutants from the City of Calgary, from a major traffic corridor (Highway 2), and from a gas plant.

On more than 280 occasions over a two-year period at Fortress Mountain, high ozone (O_3) concentrations were observed at levels comparable to those experienced in major cities. The ozone occasions were also considered significant by the scientists as the levels exceeded Alberta's air quality objective with respect to ozone. The Alberta ozone standard for one hour is 80 ppb (parts per billion).

Through further study, the scientists concluded that the high ozone concentrations were probably not due to locally produced ozone or due to the downward movement of ozone from the stratosphere.(The stratosphere is the space approximately 15 to 50 km above the surface of the earth. There is an extremely large natural layer of ozone in this space. On rare occasions, ozone from this layer is known to move downward, particularly to high elevations such as mountain tops.)

Ozone was the one pollutant at Fortress Mountain that the scientists were able to detect at levels greater than those considered within the range of global concentrations. (Global concentration is the term used by scientists to describe air quality in pristine areas, little influenced by man's activities.)

High hourly O_3 concentrations also occurred at Crossfield during the same period as Fortress Mountain (April-June, 1987). Based on detailed analysis, it appeared probable that on "episode" days, ozone in air masses arriving at Fortress Mountain was subsequently carried along the downslope of the mountain, to the Crossfield sites.

Step 3: As sulphur oxides (SO_X) and nitrogen oxides (NO_X) are major contributors to acid deposition, a detailed inventory of these emissions – accurately identified as to location – was prepared for Alberta. This is the most comprehensive inventory in the province, and it has been recognized internationally for its design and completeness.

The emission inventory identified 565 individual sources of SO_X and 4,025 sources of NO_X. The major source of both SO_X and NO_X is the petroleum industry. Other sources are electric power plants (NO_X and SO_2), major highways (NO_X) and urban centres (NO_X).

Step 4: Through the use of models, the next step was to "predict" or simulate the possibility of any regional scale environmental effects on crops, soils and surface waters. Models are mathematical simulations which help predict a probable result or effect based on data fed into them by the scientists. Many models are based on experimentation, and those used in this study were approved by the Science Advisory Board as the most appropriate for Alberta.

Research in the field was not a part of this study. The advantage of modelling work is that it identifies sensitive geographic areas, crops, soils or water bodies, so that future research can be more productive.

According to Principal Investigator Dr. Legge, "The modelling approach taken was extremely conservative, in the sense that it overestimated the impact of the pollutants. The models were far more likely to predict an effect where there was none, than to fail to predict an effect that was actually occurring."

In identifying the types of research that would be the most productive in the future, the Science Advisory Board recommended that the results of the models be verified by field and laboratory studies in the areas identified as sensitive. Forests were not included in the scientists' work with the models (although a literature review was completed in this area). The SAB has recommended future work in forested areas.

Recommendations of the Biophysical Research Team

Note: These recommendations are taken directly from the research team's report.

Effects cannot be evaluated without knowing the magnitude of the causal factors, and **modelling is no substitute for in situ measurement.** Systematic measurement is a necessary precondition to the improvement of models, which can permit interpolation between widely spaced monitoring sites.

Experience during the program (to **Critical Point I**) showed that **a number of atmospheric monitoring instruments recorded little of consequence. Future monitoring stations should continuously record O_3 and SO_2, but the bulk of the other pollutants of concern can be better determined using integrated samplers with vastly lower detection limits, such as the annular denuder.** It would also be of great value to **maintain a background measurement station,** both in terms of the fundamental knowledge gain, and for further study of the long-range transport of O_3 into the Province. **Simultaneous recording of meteorological parameters is essential to experimentally determine the rates of dry deposition of atmospheric pollutants. Studies of precipitation chemistry are required to determine wet deposition in selected areas.**

In view of the possibility of an environmental effect on alfalfa yields in the eastern portion of Region 7 (in the Edmonton area), **studies should be carried out in that region to ascertain the possible impact of combined sulphur dioxide and ozone on alfalfa yields.** Information from these studies would improve the statistical model, making it more applicable to the Alberta environment and Alberta varieties of alfalfa. In addition, **exposure studies of both forest and the crop plants must be undertaken to improve the prediction of response to ozone, sulphur dioxide, and nitrogen oxides.**

Since Alberta has a number of areas with acid-sensitive soils, **co-ordinated atmospheric and soil monitoring, further soil characterization studies, and studies of the impact on the organic portion of these soils** need to be made in selected areas. Further studies are needed of **nutrient cycling** in both susceptible and nonsusceptible soils. **The role of microorganisms responsible for the mineralization of both litter and other soil** inputs should be integrated with these studies, and the **ability of soils to immobilize sulphate** needs to be characterized as a function of soil type. The end result of these studies should be **greatly improved models for predicting the impact of acidic inputs on soils,** particularly in forest environments.

Surface water acidification generally involves the transport of deposited acidifying substances through soils, and their modification during this process. **Candidate sites for intensive studies of surface water chemistry should be selected as areas in which soil studies will also be conducted.** The ultimate goal is **the development of integrated models** that include the effects of surrounding soils on surface water acidification. In addition, **studies should be made of the effects of acidic episodes,** such as spring runoff, on the chemistry and biota of surface waters. In order that these models be as useful as possible, **a better surface water chemistry data base must be compiled** which includes information on biota. Only with such a data base will it be possible to assess the extent and nature of the risk to the resource.

Steps should be taken, either within any continuing program or by external means, to provide for **periodic updating** of the **emission inventory** and the **world literature reviews.**

Finally, the **data already obtained comprise a major resource.** Personnel and time should be devoted to **maximizing the further reporting,** and thus utilization, of that body of information.

Specific Evaluation and Recommendations of the Biophysical Science Advisory Board

Note: These recommendations are taken directly from the Science Advisory Board's report.

A. VEGETATION

BACKGROUND

1. No regional-scale assessments of tree responses in Alberta were made prior to **Critical Point I.**

2. The alfalfa growth and SO_2 response models indicated that alfalfa yields might be lower than expected in the eastern portion of Emission Region 7.

3. Air monitoring results discussed in **Critical Point I** findings suggest that ozone levels could have potentially adverse effects on forest and crop plants.

4. At the present time, data bases required for modelling are inadequate.

RECOMMENDATIONS:

1. Because modelling results in Emission Region 7 (in the Edmonton area) suggest possible decreased yields associated with SO_2, it is recommended that limited studies be conducted to determine the accuracy and validity of such modelling in terms of the suggested cause in this area only.

2. Predictive models are desirable for forest and crop plants exposed to ozone, sulphur diox-

ide, and nitrogen oxides following suitable injury threshold determinations made via controlled air pollutant exposures.

B. SOILS

RECOMMENDATIONS

1. Because acid-sensitive soils have been identified in Alberta, it is recommended that wet and dry deposition monitoring be conducted in the vicinity of such soils to obtain data essential for assessing effects. In addition, the chemical and physical properties of such soils should be studied to provide information necessary to validate soil models.

2. Nutrient cycling and effects of temperature on the same, primarily nitrogen and sulphur, should be investigated on both acid-sensitive and non-sensitive soils to provide the basis for comparison of the parameters (e.g., O_{10}, rate of nitrate and sulphate release) of nitrogen and sulphur cycling in these soils.

3. In forest soils, it is important that work be initiated to determine the forms and quantities of various organic acids produced in the litter layer with attention being placed on their contribution to the release and movement of aluminum, soil acidification, and changes in surface water chemistry.

4. The role of microorganisms in litter decomposition should be considered commensurate with studies mentioned above.

5. Models suitable for assessing acid impacts on forest soils should be developed and validated for the environment of Alberta.

6. The capacity of forest soils for sulphate adsorption should be studied, especially in highly acidic soils.

C. SURFACE WATERS

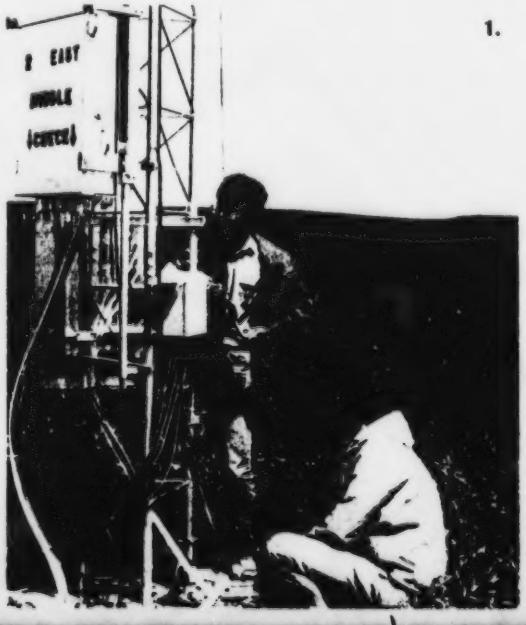
RECOMMENDATIONS

Because the modelling results for both the soils and surface water assessments indicate a potential for occurrences of acidification in sensitive areas of Alberta, we recommend that the following work be undertaken:

1. Develop a high quality surface water chemistry data-base including information on biota to permit more accurate assessment of the extent and nature of the resource at risk. (An exemplary model is the "Adirondacks Lake Survey Corporation" which represents a collaboration effort between the industry and government in New York State.)

2. Focus on forested areas and conduct integrated forest watershed/surface water effects studies in sensitive areas. Include studies of the potential effects of acidic episodes on the chemistry and biota of surface waters.

3. Examine the relationship among forest soil/surface water interactions and natural surface water acidification processes.



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1. The University of Calgary's Kananaskis Centre for Environmental Research, the prime research contractor for this Acid Deposition Research Program study, developed the KAP Sampler or Kananaskis Atmospheric Pollution Sampler. The Sampler, which was supported on this remote tower at the air monitoring sites, is an example of some of the state-of-the-art technology used in the program. It helped scientists analyze the chemical composition of Alberta's atmosphere.

D. AIR QUALITY

RECOMMENDATIONS

1. Background and several additional rural monitoring sites should be established in the province of Alberta to measure ozone (O_3), sulphur dioxide (SO_2), nitrous acid (HNO_2), nitric acid (HNO_3), ammonia (NH_3), aerosol composition (e.g., elemental composition, nitrates, and sulphates), and rain chemistry to validate presently predicted future effects of industrial emissions on vegetation, soils, water resources, and air quality.

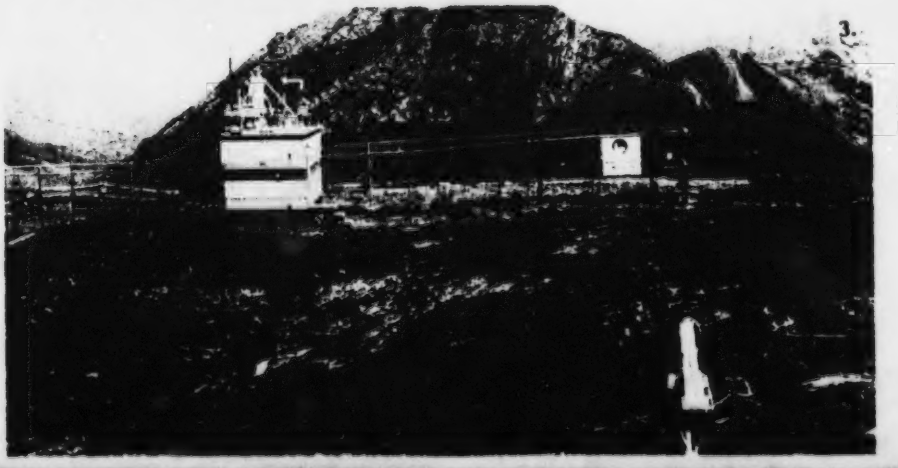
2. The enormous amount of air quality data, models, meteorology, emission inventory, and related information generated as part of ADRP should be processed and published in the peer reviewed literature. In order to prepare these publications, resources beyond the termination date of the ADRP need to be provided to satisfy this recommendation.

3. The wet and dry deposition flux measurements provided baseline data that quantify the types and amounts of acid deposition, as well as the relative magnitudes of wet and dry fluxes. These data are of the highest quality, and they set the state of the art in deposition in North America. The dry flux measurements are still of higher uncertainty than those for the more easily measured wet flux.

2.

2.

As rain is a very unstable solution, Acid Deposition Research Program scientists used a refrigerated rain sampler to collect samples which were analyzed to determine composition and pollutants carried in the rain.



3.

3.

Fortress Mountain was one of three air quality monitoring sites for the Acid Deposition Research Program study. The Science Advisory Board, an international team of air pollution scientists, have said that the data gathered at Fortress will serve as a benchmark for North America.

Nitrogen dioxide (NO_2) emitted by automobiles, trucks etc. and by sources burning fossil fuels is converted in the presence of sunlight to nitric oxide (NO) and atomic oxygen (O). Atomic oxygen (O) can combine with molecular oxygen (O_2) to form ozone (O_3). This is the major mechanism of ozone production close to the surface of the earth (in the troposphere).

SUNLIGHT

$$NO_2 \longrightarrow NO + O$$

$$O + O_2 \longrightarrow O_3$$

There are "good" and "bad" aspects to ozone.

There is concern now about the erosion or deterioration of the ozone layer in the stratosphere. This ozone in the stratosphere filters out or reflects much of the ultraviolet radiation produced by the sun, thus preventing it from reaching the earth's surface. On the other hand, increases in concentration of ozone near the earth's surface, as a result of modern industrial activities and petroleum products used in vehicles, is known to be detrimental to our environment because it can cause crop and vegetation damage and has been linked to certain respiratory health problems in humans and animals.

The members of the ADRP's Biophysical Science Advisory Board. From left to right back row: **Dr. R.N. Kickert,** Consultant (in modelling); **Dr. T.C. Weidensaul,** Ohio Agricultural Research and Development Center, Ohio State University; **Dr. S.V. Krupa,** SAB Chairman, Department of Plant Pathology, University of Minnesota; **Dr. C.L. Schofield,** Department of Natural Resources, Cornell University; **Dr. H.C. Jones,** Fisheries and Aquatic Ecology Branch, Tennessee Valley Authority; **Dr. H.M. Liljestrand,** Department of Civil Engineering, University of Texas (front row); **Dr. D.P. Ormrod,** Department of Horticultural Science, University of Guelph; **Mr. R.K. Stevens,** U.S. Environmental Protection Agency; **Dr. J.P. Lodge,** Editor, Atmospheric Environment, Consultant in Atmospheric Chemistry; and **Dr. M.A. Tahatabi,** Department of Agronomy, Iowa State University. Not pictured: **Dr. C.M. Bhumralkar,** National Oceanographic and Atmospheric Administration (NOAA).

Communications — An Integral Part of the ADRP

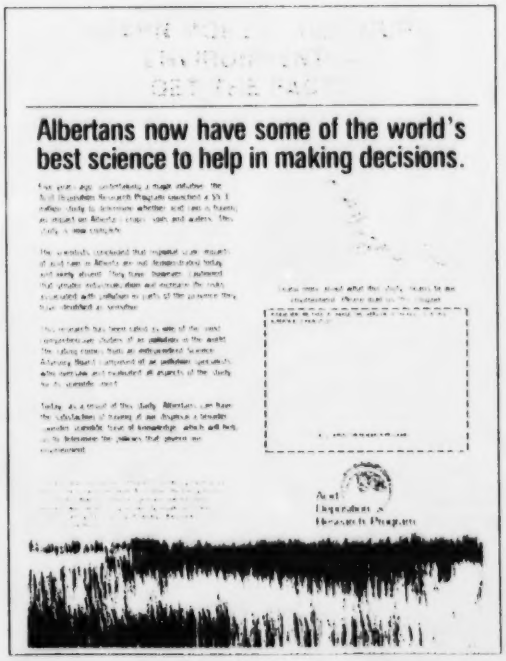
Throughout the planning phases and implementation of the Acid Deposition Research Program communications with a wide range of publics has been a priority. Background materials, newsletters, annual reports, workshops and forums, speaking engagements, newsconferences and on-going media relations updated interested Albertans and others on research progress and goals. In addition, research publications were provided at no charge to all Alberta libraries, and Canadian university and environmental libraries.

Over the course of the program, the ADRP's communications work won four awards of excellence from professional associations in the communications business. The most recent award was in 1989 from the Canadian Public Relations Society -- Calgary Chapter for the ad program conveying the final results of the ADRP's work.

In planning the ADRP's final communications program, a public opinion poll of Albertans indicated that 91% had a great deal of interest in hearing about the results of our work -- directly from the ADRP.

With this information and the urging and support of our Public Advisory Board, and as a complement to other communications efforts, the ADRP placed an informational ad in Alberta's daily and community newspapers and newsmagazines in order to reach a wider audience of Albertans. As a result of the ad, more than 2,000 requests for additional information were received by the ADRP.

In the Public Advisory Board's final report it was noted: "...a large number of interested groups and individuals had access to the findings as a result of the efforts of the ADRP advertising program conducted in the provincial print media. This was the first for a research program and has proven to be successful. The advertising campaign and number of people reached should be documented and shared with other research programs around the world."



Special Report — Public Advisory Board

The following summary has been taken directly from the document "Public Advisory Board, Report on Critical Point One of the Acid Deposition Research Program."

Individuals on the Public Advisory Board come from the following areas:

Dr. Lochan Bakshi
Athabasca University; and Vice-Chairman, Public Advisory Committee, Environment Council of Alberta

Herman Bulten
Christian Farmers Federation and other agricultural associations

Dennis Gogal
Environmental and Outdoor Education Council, Alberta Teachers' Association

Dr. Dixon Thompson
University of Calgary; and Science Advisory Committee Environment Council of Alberta; and Alberta Society of Professional Biologists; and Canadian Society of Environmental Biologists

Dr. Nicholas Bayliss
Alberta Health Care Associations

Hank Gauthier
Energy and Chemical Workers Union

Sam Sinclair
Alberta Aboriginal Peoples

Prof. Eric Tollefson
University of Calgary; and Association of Professional Engineers, Geologists and Geophysicists of Alberta

Susie Washington
Moderator, Public Advisory Board

The Public Advisory Board (PAB) commends the work of the Acid Deposition Research Program (ADRP) and endorses the recommendations of the Biophysical Research Scientific Advisory Board (SAB). The results of the study are good news in the sense that Albertans have time to act to prevent the development of serious pollution problems that currently face many other regions of Canada and the world. Moreover, the baseline data developed from the methods employed by the biophysical research team is a significant first step toward establishing new standards of study.

Albertans have a reason to be proud of the research but we cannot afford to become complacent. Although Alberta may have relatively clean air at the present time, we must be vigilant for the future. We also cannot afford to look at Alberta in isolation from the rest of our planet. If we are to meet the challenge of managing acid gas emissions and the challenge of sustainable development, as recommended by the National Task Force on Environment and Economy, there must be a sense of purpose and strong leadership.

In order to create the new institutional arrangements necessary, we must more effectively manage our environment and economy. In other words, having spent the funds on the research done to date, follow-up mechanisms must be put in place to ensure that the excellent work of the ADRP does not sit on a shelf.

Thus, notwithstanding the importance of the findings of the Biophysical Study, the PAB has not limited its discussion to the scientific issues resulting from the study. Rather, the PAB has also

focused on policy, legislative and social issues arising from the Biophysical Study. In general, we believe the decisions now facing the ADRP Members Committee are no longer the scientific measurement questions of "how to" or "how much". Rather the questions now facing the ADRP Members Committee, and the sectors represented, are the questions of goals, priorities, and consequences. Moreover, there is a need to address what new policy and legislation needs to be put in place to meet the challenge of these goals and priorities.

The recommendations for change set out in the Report on Critical Point One are not necessarily new suggestions. They represent a consolidation of existing trends in research, policy development and practice and build upon the findings of the biophysical research. They also build on the mandate for action suggested by The National Task Force on Environment and Economy and the successful models of multi-sectoral (round table) discussions used by the ADRP Public Advisory Board and the Alberta Task Force on Enforcement. The expanded and re-organized Public Advisory Board has allowed for an interactive consultative process and, more importantly, one that has helped the ADRP Members Committee to produce better decisions. It is a proven, successful model for the future and should be used again. Success has been measured by the extent to which balance has been achieved between the various interests and consensus reached on steps for actions.

The following are a summary of specific suggestions and conclusions. (The complete report discusses these recommendations in detail.)

Summary of Recommendations

The Public Advisory Board of the Acid Deposition Research Program has made recommendations in three areas: Science, Policy and Legislation and Social Issues. The key recommendations are as follows:

Science

1. There is a need for Alberta Environment to establish a long-term air quality monitoring program for the entire province. The program needs to include stations that monitor air entering the province, stations that monitor the air quality leaving the province, and stations for identified sensitive areas -- including those in the northern part of the province.

2. There is a need for Alberta Environment and Environment Canada to re-establish the baseline monitoring station at Fortress Mountain.

3. There is a need for Alberta Agriculture to conduct veterinary medical health studies as recommended by the Veterinary Medical Health Workshop. There is also a need for Alberta Agriculture, in concert with Alberta Environment, to validate models of alfalfa growth as recommended by the ADRP's Science Advisory Board of the Biophysical Research Program.

4. There is a need for Alberta Technology, Research and Telecommunications to work with the scientists of the ADRP and industry to review the air quality monitoring methods as used in the ADRP to discover possible pollution control technologies that can be developed for commercial purposes.

Policy and Legislation

1. There is a critical need for the Government of Alberta to work with industry to develop an incentive program to enable the phasing out of older industrial facilities or the retrofitting of these plants with updated pollution control technology.

2. There is a need for the Government of Alberta and industry to establish an environmental clean-up fund.

3. There is an immediate need for the Government of Alberta to develop the legislative amendments as recommended by the Task Force on Environmental Enforcement, to make the Clean Air Act enforceable.

4. There is a need for the Government of Alberta to co-ordinate efforts that include industry and the public, working toward the concept of a "clean-air bubble" for the province -- **before** there are air quality problems.

Social Issues

1. Complex environmental problems demand an educated public. Alberta Education must include environmental education as part of the primary and secondary school core curriculum to meet this challenge.

2. Finally, and as explicitly noted in many of the detailed recommendations, there is an on-going need for additional consultative approaches to problem-solving for environmental protection. If we are to solve the problems for today and for the future, government as well as industry and non-government organizations must participate in the planning, design and implementation of new legislation and new systems of administration. As well as being more effective, this approach is also cost effective in terms of both time and money.

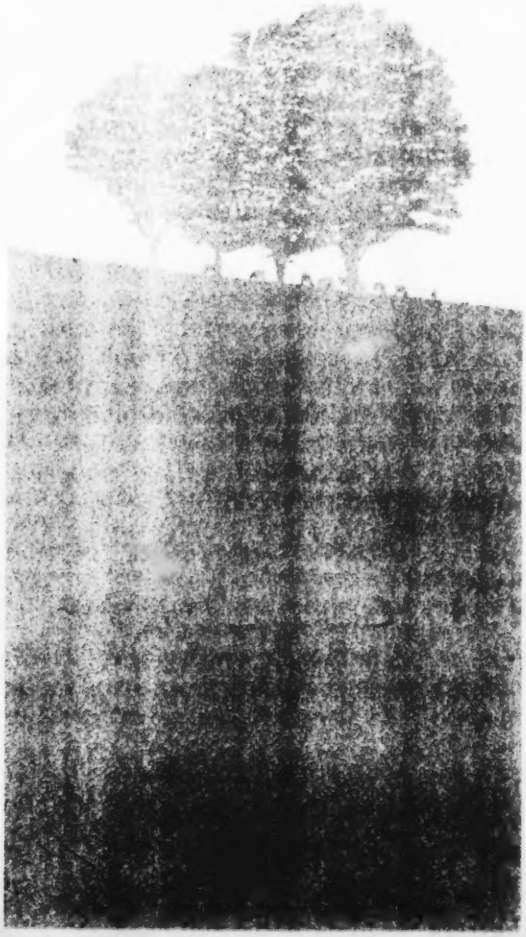
Specific multi-sectoral discussions are recommended for many of the proposed recommendations, including:

a. northern Alberta research program;

b. veterinary medical health program;

c. industry environmental protection incentive program; and

d. new approaches to the management of Alberta's air quality.



ADRP Organization

A. Committees

Biophysical Technical Research Advisory Committee

Dr. John Railton, Chairman
Monenco Consultants Limited
(utilities group representative)

Randy Angle
Alberta Environment

Earle Baddaloo
Alberta Environment

Lin Callow
Gulf Canada Resources

David McCoy
Canterra Energy Ltd.

Technical Research Advisory Committee — Human Health

Dr. Linton Kulak, Chairman
Shell Canada Limited

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Alberta Community and Occupational Health

Ed A. Collom
Alberta Community and Occupational Health

Dr. Dennis Stokes
Alberta Environment

Communications Committee

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Energy Resources Conservation Board

Douglas Bruchet
Canadian Petroleum Association

Jean L. Andryiszyn,
Communications Co-ordinator

Susie Washington, Moderator,
Public Advisory Board

Dr. Ron R. Wallace, Program Manager

B. Scientific Advisory Board – Biophysical Research

Dr. Sagar V. Krupa, Chairman SAB
University of Minnesota
(Department of Plant Pathology)

Dr. C. M. Bhumralkar
National Oceanographic
and Atmospheric Administration (NOAA)

Dr. Herbert C. Jones
Tennessee Valley Authority
Fisheries and Aquatic Ecology Branch

Dr. Ron Kickert
Consultant (in modelling)

Dr. H. M. Liljestrand
University of Texas
(Department of Civil Engineering)

Dr. James P. Lodge
Consultant in Atmospheric Chemistry
and Editor, *Atmospheric Environment*

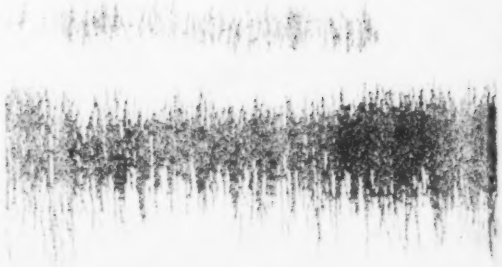
Dr. Douglas P. Ormrod
University of Guelph
Department of Horticultural Science

Dr. Carl L. Schofield
Cornell University
(Department of Natural Resources)

Dr. Robert K. Stevens
U.S. Environmental Protection Agency

Dr. M. Ali Tabatabai
Iowa State University
(Department of Agronomy)

Dr. T. Craig Weidensaul
Ohio Agricultural Research
and Development Center
Ohio State University



C. Scientific Advisory Board – Human Health Research

Benjamin Burrows, M.D.,
Chairman SAB
Professor of Internal Medicine
Director
Division of Respiratory Sciences
University of Arizona

Dr. Zoltan Annau
Professor
Department of Environmental Health Services
The Johns Hopkins University
School of Hygiene and Public Health

Gerry Hill, M.D.
Director
Department of Epidemiology
Alberta Cancer Board
Edmonton, Alberta

Walter Mertz, M.D.
Director
Human Nutrition Research Center
Agriculture Research Center
U.S. Department of Agriculture

Jonathan M. Samet, M.D.
Associate Professor of Medicine
Department of Medicine
University of New Mexico

Mark J. Utell, M.D.
Associate Professor of Medicine and Toxicology
Co-Director
Pulmonary and Critical Care Unit
University of Rochester School of Medicine

D. Prime Research Contractors

Biophysical Research

Kananaskis Centre for
Environmental Research,
The University of Calgary

Principal Investigator:
Dr. Allan H. Legge

Medical Diagnostic Review

The McGill Inter-University
Research Group

Principal Investigator:
Dr. W.O. Spitzer

Occupational Health-Feasibility Study

Department of Health Services
Administration and Community
Medicine,
Faculty of Medicine,
University of Alberta

Principal Investigator:
Dr. Tee Guidotti

Research Reports Published by the Acid Deposition Research Program

The complete final report **"Acidic Deposition: Sulphur and Nitrogen Oxides, the Alberta Government Industry Acid Deposition Research Program, A Case Study"**, editors A.H. Legge, S.V. Krupa, will be available in 1989 through Lewis Publishers Ltd., Chelsea, Michigan or John Wiley and Sons, Toronto.

WORLD LITERATURE REVIEWS

ADRP Report Number	Microlog Number
☐ ADRP-B-01-87	88-00571/

Tetlang, S. A., 1987
Surface Water Acidification Literature Review. Prep. for the Acid Deposition Research Program by the Kananaskis Centre for Environmental Research, The University of Calgary, Calgary, Alberta, Canada. 123 pp.
ISBN 0-921625-03-0 (Volume 1)
ISBN 0-921625-02-2 (Set of 11)

☐ ADRP-B-02-87	88-00572/

Visser, S., Danielson, R. M. and Parr, J. F., 1987
Effects of Acid-Forming Emissions on Soil Microorganisms and Microbially-Mediated Process. Prep. for the Acid Deposition Research Program by the Kananaskis Centre for Environmental Research, The University of Calgary, Calgary, Alberta, Canada and U.S. Department of Agriculture, Beltsville, Maryland, U.S.A., 86 pp.
ISBN 0-921625-04-9 (Volume 2)
ISBN 0-921625-02-2 (Set of 11)

☐ ADRP-B-03-87	88-00573/

Krouse, H. R., 1987
Environmental Sulphur Isotope Studies in Alberta: A Review. Prep. for the Acid Deposition Research Program by the Department of Physics, The University of Calgary, Calgary, Alberta, Canada. 89 pp.
ISBN 0-921625-05-7 (Volume 3)
ISBN 0-921625-02-2 (Set of 11)

☐ ADRP-B-04-87	88-00574/

Lashley, E. J. and Bryant, R., 1987
Critical Review of Inorganic Sulphur Microbiology with Particular Reference to Alberta Soils. Prep. for the Acid Deposition Research Program by the Department of Biology, The University of Calgary, Calgary, Alberta, Canada. 56 pp.
ISBN 0-921625-06-5 (Volume 4)
ISBN 0-921625-02-2 (Set of 11)

☐ ADRP-B-05-87	88-00575/

Turchenek, L. W., Abboud, S. A., Thomas, C. J., Fessenden, R. J. and Holowaychuk, N., 1987
Effects of Acid Deposition on Soils in Alberta. Prep. for the Acid Deposition Research Program by the Alberta Research Council, Edmonton, Alberta, Canada. 202 pp.
ISBN 0-921625-07-3 (Volume 5)
ISBN 0-921625-02-2 (Set of 11)

ADRP Report Number	Microlog Number
☐ ADRP-B-06-87	88-00576/

Jaques, D. R., 1987
Major Biophysical Components of Alberta. Prep. for the Acid Deposition Research Program by Ecosat Geobotanical Surveys Inc., 108 pp.
ISBN 0-921625-08-1 (Volume 6)
ISBN 0-921625-02-2 (Set of 11)

☐ ADRP-B-07-87	88-00577/

Campbell, K. W., 1987
Pollutant Exposure and Response Relationships: A Literature Review. Geological and Hydrogeological Aspects. Prep. for the Acid Deposition Research Program by Subsurface Technologies and Instrumentation Limited, Calgary, Alberta, Canada. 152 pp. + maps
ISBN 0-921625-09-X (Volume 7)
ISBN 0-921625-02-2 (Set of 11)

☐ ADRP-B-08-87	88-00578/

Torn, M. S., Degrange, J. E. and Shinn, J. H., 1987
The Effects of Acidic Deposition on Alberta Agriculture: A Review. Prep. for the Acid Deposition Research Program by the Environmental Sciences Division, Lawrence Livermore National Laboratory, 160 pp.
ISBN 0-921625-10-3 (Volume 8)
ISBN 0-921625-02-2 (Set of 11)

☐ ADRP-B-09-87	88-00579/

Mayo, J. M., 1987
The Effects of Acid Deposition on Forests. Prep. for the Acid Deposition Research Program by the Department of Biology, Emporia State University, 74 pp.
ISBN 0-921625-11-1 (Volume 9)
ISBN 0-921625-02-2 (Set of 11)

☐ ADRP-B-10-87	88-00580/

Krupa, S. V. and Kickert, R. N., 1987
An Analysis of Numerical Models of Air Pollutant Exposure and Vegetation Response. Prep. for the Acid Deposition Research Program by the Department of Plant Pathology, University of Minnesota, St. Paul, Minnesota, U.S.A., and Consultant, Corvallis, Oregon, U.S.A., 133 pp.
ISBN 0-921625-12-X (Volume 10)
ISBN 0-921625-02-2 (Set of 11)

☐ ADRP-B-11-87	88-00616/

Legge, A. H. and Crowther, R. A., 1987
Acidic Deposition and the Environment: A Literature Overview. Prep. for the Acid Deposition Research Program by the Kananaskis Centre for Environmental Research, The University of Calgary, Calgary, Alberta, Canada. 245 pp.
ISBN 0-921625-13-8 (Volume 11)
ISBN 0-921625-02-2 (Set of 11)

BIOPHYSICAL RESEARCH

SUMMARY REPORT — CRITICAL POINT ONE

ADRP Report Number	Microlog Number
☐ ADRP-B-16-88	88-00584

Legge, A.H., 1988
The Present and Potential Effects of Acidic and Acidifying Air Pollutants on Alberta's Environment. Critical Point I, 1988. Summary Report. Prep. for the Acid Deposition Research Program by The Kananaskis Centre for Environmental Research, The University of Calgary, Alberta, Canada. 79 pp.
ISBN 0-921625-23-5

EMISSION INVENTORY

ADRP Report Number	Microlog Number
☐ ADRP-A-1-87	88-00581/

Picard, D. J., Colley, D. G. and Boyd, D. H., 1987
Overview of the Emission Data: Emission Inventory of Sulphur Oxides and Nitrogen Oxides in Alberta. Prep. for the Acid Deposition Research Program by Western Research, Division of Bow Valley Resource Services Ltd., Calgary, Alberta, Canada.
ISBN 0-921625-18-9 (Volume 1)
ISBN 0-921625-17-0 (Set of 4)

☐ ADRP-A-2-87	88-00582/

Picard, D. J., Colley, D. G. and Boyd, D. H., 1987
***Design of Emission Inventory: Emission Inventory of Sulphur Oxides and Nitrogen Oxides in Alberta.** Prep. for the Acid Deposition Research Program by Western Research, Division of Bow Valley Resource Services Ltd., Calgary, Alberta, Canada.
ISBN 0-921625-19-7 (Volume 2)
ISBN 0-921625-17-0 (Set of 4)

☐ ADRP-A-3-87	88-00583/

Picard, D. J., Colley, D. G. and Boyd, D. H., 1987
***Emission Data Base: Emission inventory of Sulphur Oxides and Nitrogen Oxides in Alberta.** Prep. for the Acid Deposition Research Program by Western Research, Division of Bow Valley Resource Services Ltd., Calgary, Alberta, Canada.
ISBN 0-921625-20-0 (Volume 3)
ISBN 0-921625-17-0 (Set of 4)

☐ ADRP-A-4-87	88-00584/

Picard, D. J., Colley, D. G. and Boyd, D. H., 1987
***Results of the Emission Source Surveys: Emission Inventory of Sulphur Oxides and Nitrogen Oxides in Alberta.** Prep. for the Acid Deposition Research Program by Western Research, Division of Bow Valley Resource Services Ltd., Calgary, Alberta, Canada.
ISBN 0-921625-21-9 (Volume 4)
ISBN 0-921625-17-0 (Set of 4)

*Detailed data compilations, of technical interest.

HUMAN HEALTH PROGRAM

Microlog Number

87-00668/10

Spitzer, W. O. and The McGill Interuniversity Research Group. 1986
The Southwestern Alberta Medical Diagnostic Review, Volume One — Methodology. Prep for the Acid Deposition Research Program by the Department of Epidemiology and Biostatistics, McGill University, Montreal, Quebec, Canada. 308 pp.
ISBN 0-921625-14-6 (Volume 1)
ISBN 0-921625-00-6 (Set of 4)

87-00668/10

Spitzer, W. O. and The McGill Interuniversity Research Group. 1986.
The Southwestern Alberta Medical Diagnostic Review, Volume Two — Results. Prep for the Acid Deposition Research Program by the Department of Epidemiology and Biostatistics, McGill University, Montreal, Quebec, Canada. 542 pp.
ISBN 0-921625-15-4 (Volume 2)
ISBN 0-921625-00-6 (Set of 4)

87-00668/10

Spitzer, W. O. and The McGill Interuniversity Research Group. 1986.
The Southwestern Alberta Medical Diagnostic Review, Summary — Methods and Results. Prep for the Acid Deposition Research Program by the Department of Epidemiology and Biostatistics, McGill University, Montreal, Quebec, Canada. 104 pp.
ISBN 0-921625-16-2 (Volume 3)
ISBN 0-921625-00-6 (Set of 4)

87-00668/10

Spitzer, W. O. and The McGill Interuniversity Research Group. 1986.
The Southwestern Alberta Medical Diagnostic Review, Appendix I — Supplementary Detailed Methods and Specific Results. Prep for the Acid Deposition Research Program by the Department of Epidemiology and Biostatistics, McGill University, Montreal, Quebec, Canada.

87-00998/1

Burrows, B., Annau, Z., Samet, J. M., Hill, G., Mertz, W. and Utall, M. J. (Science Advisory Board, ADRP). 1986.
Final Report of the Science Advisory Board to the Medical Diagnostic Review Program. Prep for the Acid Deposition Research Program. 31 pp.
ISBN 0-921625-01-4 (Volume 4)
ISBN 0-921625-00-6 (Set of 4)

ADRP FACT SHEETS

1. An Overview of the Acid Deposition Research Program – 1988
2. An Overview of the Southwest Alberta Medical Diagnostic Review 1985/86 (Pincher Creek Health Study)
3. An Overview of Research Results: The Present and Potential Effects of Acid Deposition in Alberta – 1988

All the reports listed have been provided — at no charge — to all University libraries in Canada, and specialized environmental libraries. All Alberta libraries have been provided with the summary volumes of the reports. Reports are registered with the National Library of Canada, and the U.S. Department of Commerce National Technical Information Service.

Microfiche or paper copies are available through:
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Toronto, Ontario M5H 1L3
(416) 593-5211
Toll Free 1-800-387-2689

Please cite the microlog numbers when ordering.

Statement of Income and Expenditures

For the program from 1983 to March 31, 1989

Source of Funds:	
Members — ADRP	$ 6,593,260
Interest	106,740
*Alberta Community and Occupational Health	3,700,000
	$10,400,000
Expenditures:	
Biophysical Research	$ 5,309,677
Occupational Health Research	25,000
*Southwest Alberta Medical Diagnostic Review	3,700,000
Program Support	1,365,323
• Communications/information/education	
• Administration	
• Research report publication, public distribution	
	$10,400,000

*Alberta Community and Occupational Health funded the Southwest Alberta Medical Diagnostic Review (Pincher Creek Health Study), which was administered by the ADRP.

Detailed audited statements and reconciliations will be available in the fourth quarter of 1989. They can be obtained by writing: **The Acid Deposition Research Program**
3800, 150 - 6 Avenue S.W.
Calgary, Alberta T2P 3Y7